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(54) Title: FLEXIBLE FREQUENCY-TIME DIVISION DUPLEX IN RADIO COMMUNICATIONS SYSTEMS

(57) Abstract

A flexible channel architecture supports full-duplex, radio-frequency communication between a base station, such as a PWT or DECT base station, and a group of remote terminals. Downlink communication from the base to the terminals is by way of a first radio-frequency carrier, and uplink communication from the terminals to the base is by way of a first radio-frequency carrier, and uplink communication from the terminals to the base is by way of a second radio-frequency carrier. Each carrier is organized to provide an N-timeslot time-division multiple access data stream (N an integer), so that together the two carriers provide a 2N-timeslot system. Within each frame, data from the base to a terminal is sent on the first carrier during a first time slot, and data from the terminal to the base is sent on the second carrier during a second time slot, the first and second time slots being offset by a time offset which can vary across communications links. The disclosed system provides a unified architecture which allows a single time-division multiple-access hardware platform to efficiently and selectively support either time-division duplex or frequency-division duplex.

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FLEXIBLE FREQUENCY-TIME DIVISION DUPLEX IN RADIO COMMUNICATIONS SYSTEMS

Field of the Invention

The present invention relates to radio communications systems, and more particularly to duplex schemes in time-division multiple-access (TDMA) systems.

Background of the Invention

Most time-division multiple-access wireless communications systems employ either a time-division duplex (TDD) scheme or a frequency-division duplex (FDD) scheme to separate uplink and downlink transmissions. Since both duplex schemes provide certain advantages and disadvantages, both schemes are routinely utilized in wireless communications applications.

For example, in the Personal Wireless Telecommunication (PWT) standard, time-division multiple-access with time-division duplex is used for frequency planning as well as signal packet and time slot assignment. Such a time-division multiple-access / time-division duplex scheme is well suited for many business wireless communication applications (e.g., small-campus systems with micro or pico cells).

On the other hand, time-division multiple-access with either time-division duplex or frequency-division duplex can be preferable for licensed Personal Communication Service (PCS) frequency bands, depending upon customer demands and marketplace requirements. In other words, since the structure of a Personal Communications Service system is primarily determined by a service provider having acquired a portion of the frequency spectrum, the technology and

frequency usage implemented in such a system is ultimately driven by customer demand as well as legal and practical constraints. While a first customer may request a time-division multiple access / time-division duplex system for a particular business wireless application, a second customer may thereafter demand a time-division multiple access / frequency-division duplex system for a wireless local loop application.

Thus, service providers are often required to convert between duplex schemes. Converting between schemes, however, typically results in duplicated effort and therefore wastes significant time and resources. For example, since the conventional time-division duplex and frequency-division duplex schemes are fundamentally different, it generally is not feasible to use a common hardware platform for both types of system. As a result, two development teams are typically assigned, and two separate product lines are usually established, to provide for both time-division duplex and frequency-division duplex implementations.

Thus, there is a need for a flexible duplex scheme which will allow a communications system to be adapted to satisfy varying customer needs without requiring modification of basic system hardware architecture.

Summary of the Invention

The present invention fulfills the above-described and other needs by providing a flexible division duplex mechanism in a time-division multiple-access communications system. More specifically, the disclosed system utilizes a mixed, or hybrid, division duplex mechanism such that uplink and downlink transmissions are separated in frequency while time slots associated with transmission and reception are also separated in time. The hybrid duplex scheme, referred to herein as frequency-time division duplex (FTDD), allows alternative division

duplex mechanisms to be selectively implemented within a communications system without requiring modification of the basic system hardware architecture.

The frequency-time division duplex system of the present invention provides the advantages of low power consumption and reduced hardware complexity normally associated with conventional time-division multiple-access / time-division duplex systems, while also providing improved interference characteristics by separating uplink and downlink frequency bands. Further, the proposed system allows a single hardware platform to be used for multiple technologies and applications. For example, base stations designed for a business wireless system based on time-division multiple-access / time-division duplex technology can also be used, with minor changes, for wireless local loop (WLL) applications conventionally based on time-division multiple-access / frequency-division duplex technology. Thus, embodiments of the invention allow the non-recurring engineering costs typically associated with technology and product development to be substantially reduced. As a result, development schedules and production cycles for implemented systems can be shortened, and service and product providers can respond more quickly to customer and market demand.

According to an exemplary embodiment, a base station includes a transceiver configured to transmit downlink communications signals to mobile stations via a first carrier frequency and to receive uplink communications signals from the mobile stations via a second carrier frequency, the downlink and uplink communications signals being transmitted and received via successive time division multiple access frames, each frame including a plurality of time slots. For each active communications link between said the station and a particular mobile station, a first time slot in each frame is allocated for downlink communication to the particular mobile station and a second time slot in each frame is allocated for uplink communication from the particular mobile station,

the first and second allocated time slots being separated in time by a fixed time offset. Advantageously, a duration of the fixed time offset can be different for each active communication link (e.g., for each call established). For example, where each frame is of duration T and includes 2N time slots, each time slot being of duration T/2N, the fixed time offset for each active communication link can be $\Delta T = (T/2N)*m$, where m is an integer in the range from 1 to 2N-1.

According to an alternative embodiment, a base station includes a transceiver configured to transmit downlink communications signals to mobile stations via a first carrier frequency and to receive uplink communications signals from the mobile stations via a second carrier frequency, the downlink and uplink communications signals being transmitted and received via successive time division multiple access frames, each frame including a plurality of time slots. Advantageously, a downlink signal processing path and an uplink signal processing path of the transceiver share common signal processing components. For example, the shared signal processing components can include one or more of a filter, a local oscillator and a modem.

The above described and additional features of the present invention are explained in greater detail hereinafter with reference to the illustrative examples shown in the accompanying drawings. Those skilled in the art will appreciate that the described embodiments are provided for purposes of illustration and understanding and that all equivalent embodiments are contemplated herein.

Brief Description of the Drawings

Figure 1 depicts an exemplary wireless communications system in which the teachings of the present invention can be implemented.

Figure 2A depicts a base station and a mobile station communicating in accordance with a conventional time-division multiple-access / time-division duplex scheme.

Figure 2B depicts an exemplary time slot arrangement in a conventional time-division multiple-access / time-division duplex system.

Figure 3A depicts a base station and a mobile station communicating in accordance with a conventional time-division multiple-access / frequency-division duplex scheme.

Figure 3B depicts an exemplary time slot arrangement in a conventional time-division multiple-access / frequency-division duplex system.

Figure 4A depicts a base station and a mobile station communicating in accordance with a flexible time-division multiple-access / frequency-time division duplex scheme according to the present invention.

Figure 4B depicts an exemplary time slot arrangement in a flexible time-division multiple-access / frequency-time division duplex system according to the invention.

Figure 4C depicts an alternative time slot arrangement in a flexible time-division multiple access / frequency-time division duplex system according to the invention.

Figure 5 is a block diagram of an exemplary transceiver constructed in accordance with the present invention.

Detailed Description of the Invention

Figure 1 depicts a wireless communications system 100 in which the teachings of the present invention can be implemented. As shown, the exemplary

wireless system includes ten cells or coverage areas C1-C10, ten base stations B1-B10, a timing master TM and ten mobile stations M1-M10. Such a wireless system can be constructed, for example, in accordance with the Personal Wireless Telecommunication (PWT) standard, and can therefore be used, for example, to provide mobile communications within a building or throughout a campus including many buildings and open areas. Generally, a wireless system can include far more than ten cells, ten base stations and ten mobile stations; however, ten of each is sufficient for illustrative purposes.

As shown, one or more base stations can be situated in each of the cells. Although Figure 1 shows the base stations located toward the cell centers, each base station can instead be located anywhere within a cell. Base stations located toward a cell center typically employ omni-directional antennas, while base stations located toward a cell boundary typically employ directional antennas. The timing master TM, or radio exchange, maintains timing synchronization between the base stations as is known in the art. The timing master can be connected to the base stations by cable, radio links, or both.

Each base station and each mobile station includes a transceiver for transmitting and receiving communications signals over the air interface. Typically, the base and mobile stations communicate using a form of time, frequency or code division multiple access (i.e., TDMA, FDMA or CDMA) as is known in the art. As the mobile stations move within a cell and from cell to cell, communication with at least one base station is always possible. As a result, mobile station users are able to place, receive and conduct calls anywhere within the overall system coverage area.

To illuminate the features and advantages of the hybrid, frequency-time division duplex (FTDD) scheme of the present invention, conventional time-division duplex (TDD) and frequency-division duplex (FDD) schemes are

described hereafter with respect to Figures 2A, 2B, 3A and 3B. Without loss of generality, the channel definition in the Personal Wireless Telecommunication standard is used to illustrate a conventional time-division multiple-access (TDMA) / TDD system. Although channel definitions can differ between standards, the underlying multiplexing and duplexing concepts remain the same.

Figure 2A depicts uplink and downlink communication according to a conventional TDD scheme. As shown, signals transmitted from a TDD base station B20 to a TDD handset M20, and those transmitted from the TDD handset M20 to the TDD base station B20, are separated in time. If, as shown in Figure 2B, a predetermined time interval T represents the duration of a single TDMA / TDD frame T20, then the separation between uplink and downlink transmissions is typically one half of the predetermined time interval T, or T/2. In a Personal Wireless Telecommunications system, each frame is 10 milliseconds in duration and includes twenty-four data slots. Within a data frame, twelve time slots are used for transmission (from the TDD base station B20 to the TDD handset M20), and the remaining twelve time slots are used for reception (i.e., transmission from the TDD handset M20 to the TDD base station B20). Though transmissions and receptions are separated by certain fixed (or variable) time, they share a common frequency band. The channel of such a system is therefore defined by a predetermined frequency and time reference pair.

Such TDMA / TDD systems are widely adopted in various wireless communications applications. An advantage of these systems is that of frequency efficiency, as both uplink and downlink transmissions use a common frequency carrier. Additionally, since transmissions and receptions are separated in time, a single hardware path (including filters, local oscillators, etc.) can be used for both functions. As a result, TDD systems are relatively low cost. Also, since receiving hardware can be turned off during transmission (and transmitting

hardware can be turned off during reception), TDD systems consume relatively little power.

By way of contrast, frequency-division duplex (FDD) systems require separate frequency bands for uplink and downlink communications. This results from the fact that the receive and transmit operations are executed simultaneously in time at different frequencies. A channel in a FDD system is thus defined by the frequency of operation. Figure 3A depicts uplink and downlink communications between a conventional FDD base station B30 and a conventional FDD handset M30, and Figure 3B shows an exemplary TDMA / FDD frame T30. Since both transmit and receive are accomplished simultaneously, separate hardware paths are required in both base stations and terminals. As a result, FDD systems are typically higher cost and consume more power as compared to conventional TDD systems. However, FDD systems provide relatively little cross-channel interference and are sometimes preferred from an inter-system perspective. In other words, a FDD scheme may be required to make a system compatible with proximate systems using an adjacent portion of the frequency spectrum. As a result, FDD systems have also been widely adopted in wireless communications applications.

Though both TDD and FDD systems do provide certain advantages, neither is ideally suited for all wireless communications applications. Further, as described above, the fundamental differences between TDD and FDD make it difficult to adapt a system configured specifically for one or the other to conform with a particular application need. Advantageously, the present invention provides a hybrid, frequency-time division duplex (FTDD) scheme which provides certain of the advantages of both types of conventional system and which further allows a single hardware configuration to be readily adapted to suit virtually any wireless communications application.

To illustrate the FTDD system of the present invention, a TDMA data frame is defined as including 2N time slots (N an integer) in which N slots are reserved for downlink transmission from a base station to a portable and the remaining N slots are reserved for uplink transmission from a portable to a base station. Assuming, without loss of generality, that the time durations of uplink and downlink slots are u and d, respectively, then the duration T of a single frame is given by:

$$N(d+u) = T. \tag{1}$$

Since transmit and receive time slots are usually of the same time duration (i.e., $d = u$), half of the frame, or T/2, is usually reserved for downlink transmission and the remaining half of the frame is usually reserved for uplink transmission.

According to the invention, a duplex link is set up with both frequency and time separation. Specifically, the uplink frequency f_u is separated from the downlink frequency f_d by a pre-determined frequency offset Δf as follows:

$$f_u = f_d - \Delta f \tag{2}$$

or

$$f_u = f_d + \Delta f. \tag{3}$$

Equations (2) and (3) describe the frequency-division duplex aspect of the system. In addition to frequency separation, time separation is also provided. Specifically, the uplink and downlink communications between a base station and a portable are also separated by a fixed time offset. The specific time offset is based on a frame length of 2N slots with a period of T/2N seconds/slot. The time duplexing can then be defined generally for an uplink packet as $S_u(t_1)$ and for a downlink packet as $S_d(t_1 \pm \Delta T)$, where t_1 is defined as the start time of the uplink packet and

$$\Delta T = \text{time offset} = (T/2N) * m \qquad (1 \leq m \leq 2N - 1) \tag{4}$$

(m being an integer which, according to the invention, can be different for each communications link established between a base station and a mobile station). The combined time-division and frequency-division aspects of the system can thus be described generally for the uplink packet as $S_u(t_1,f_u)$ and for the downlink packet as $S_d(t_1+\Delta T,f_u\pm\Delta F)$ or $S_d(t_1-\Delta T,f_u\pm\Delta F)$.

Thus, according to the invention, uplink and downlink transmissions occur at separate frequencies and on allocated time slot pairs, one time slot pair being allocated for each active link established between a base station and a mobile station. For each active link, the allocated uplink time slot either precedes or follows the corresponding allocated downlink time slot, within each TDMA frame, by the time offset ΔT. The allocated time slot pairing is then maintained for the duration of the link.

Selection of the uplink and downlink time slots for each link can be based, for example, on a channel selection process which determines the best link arrangement. Determination of the best link arrangement can in turn be based, for example, on an assessment of adjacent-channel and/or co-channel interference existing at the time of call setup. Advantageously, either the base station or the mobile station can be responsible for time slot selection and allocation. For example, the base station can select the uplink time slot based on interference conditions at the base station, while the mobile station selects the downlink time slot based on conditions at the mobile. Alternatively, the base station can select both uplink and downlink time slots, either independently or on command from the mobile stations.

Note that, because each base station is not limited to a particular portion of a frame for uplink or downlink transmission, a single base station can be used to support portables throughout a particular coverage area. In other words, since each slot within each TDMA frame can be allocated for either uplink or downlink

transmission, and since the time offset between an allocated uplink and downlink time slot pair can be different for each active link, a single base station can communicate with a mobile station using any available time slot arrangement which may be preferable for the mobile. Of course, a single base station can support at most N duplex links simultaneously (assuming 2N time slots per TDMA frame), and if traffic conditions warrant it, a second base station can be added in the coverage area to provide for full time and spectral efficiency (i.e., both base stations together can support 2N simultaneous conversations).

Figure 4A depicts a FTDD base station B40 and a FTDD terminal M40 communicating in accordance with the above described TDMA / FTDD scheme. As shown, uplink and downlink communications are separated in both frequency and time. Figure 4B then depicts an exemplary combination of time slot pairings within a TDMA / FTDD data frame T40a for a single base station. Those skilled in the art will appreciate that the combination of pairings in Figure 4B is but one example and that every possible combination of pairings is contemplated by the invention. Furthermore, although each uplink and downlink pair in Figure 4B utilizes the same time offset (i.e., $\Delta T = T/2$), those skilled in the art will realize that each pair can use a different time offset as described above. However, assuming for purposes of illustration that the depicted time slot pairing is in effect for a first base station, Figure 4C then depicts a complimentary time slot pairing which can be used, for example, by a second co-located base station without causing interference with the first base station. Together, the first and second co-located base stations provide full time and spectral efficiency for the coverage area in which they are situated (i.e., each frequency in each time slot within each TDMA frame is utilized for either uplink or downlink communication).

According to the invention, appropriate base station synchronization is used to enable a handset to conduct communication with any base station in an

overall system. As is known in the art, such base station synchronization can be implemented via a timing master TM such as that depicted in Figure 1. In implementations in which the time offset ΔT between paired uplink and downlink time slots is variable across communications links (i.e., where each active communication link can potentially utilize a different time offset), appropriate overhead signaling is required between base stations to implement handovers (e.g., information identifying the presently allocated pair is passed between base stations during a handover). However, in implementations in which each active link utilizes a common time offset ΔT, the overhead can be significantly reduced. See, for example, copending U.S. Patent Application No. __________, entitled "Fixed Frequency-Time Division Duplex in Radio Communications Systems" filed on even date herewith, which is incorporated herein in its entirety by reference. Those skilled in the art will appreciate that the above described synchronization can be achieved via straightforward software modification of existing systems.

An exemplary embodiment of the above described TDMA / FTDD system utilizes the U.S. Personal Communication Service band definition for uplink and downlink frequencies combined with the PWT(E) time-division definition. The embodiment utilizes a fixed $\Delta T = T/2$ for all duplex links and operates with the following parameters:

$$\Delta T = T/2 = 5 \text{ msec}$$
$$\Delta F = 80 \text{ MHz}$$
$$T/2N = 416.667\ \mu\text{sec}$$
$$S_u\ (t_1, f_u)$$
$$S_d\ (t_1 \pm 5 \text{ msec},\ f_u + 80 \text{ MHz}).$$

As noted above, the TDMA / FTDD scheme of the invention provides, among other advantages, the power savings benefits typically associated with conventional TDMA / TDD systems. For example, since uplink and downlink transmissions are separated in time, the disclosed FTDD scheme enables the

transmit and receive paths of a base station or mobile station transceiver to share certain components. This aspect of the invention is depicted in Figure 5.

In Figure 5, an exemplary base station transceiver 500 includes a transmit signal processing path and a receive signal processing path. As shown, the transmit processing path includes first and second transmit blocks 510, 520, first and second transmit / receive blocks 530, 540, a local oscillator 550, a duplexor 560 and an antenna 570. Additionally, the receive signal processing path includes the local oscillator 550, the duplexor 560 and the antenna 570, as well as first and second receive blocks 580, 590.

The first transmit block 510 can include, for example, a conventional upconverter, and the second transmit block 520 can include, for example, power amplifiers and mixers. Additionally, the first receive block 580 can include, for example, low noise amplifiers (LNAs) and mixers, and the second receive block 590 can include, for example, a conventional downcoverter and limiter. The first transmit / receive block 530 can include, for example, a modem, and the second transmit / receive block 540 can include, for example, bandpass filters. The duplexor 560 can be, for example, a two-way filter or a switch.

During downlink transmission, the duplexor 560 couples the antenna 570 to the second transmit block 520 and isolates the antenna 570 from the first receive block 580. Baseband transmit signals are processed by the first transmit / receive block 530 and are then upconverted, filtered and amplified in blocks 510, 540, 520, respectively, prior to transmission via the antenna 570. Conversely, during uplink reception, the duplexor 560 couples the antenna 570 to the first receive block 580 and isolates the antenna 570 from the second transmit block 520. Radio frequency signals are received at the antenna 570 and then amplified, filtered and downconverted in blocks 580, 540 and 590, respectively, prior to being processed by the first transmit / receive block 530. Because the transmit

and receive processing paths share certain components (i.e., those components in the first and second transmit / receive blocks 530, 540, which are typically very expensive), a base station transceiver constructed in accordance with the invention can be made smaller and less costly as compared to conventional TDMA / FDD transceivers.

In sum, the present invention teaches a time-division multiple-access system including a flexible frequency-time division duplex mechanism. The disclosed system enables existing time-division multiple-access / time-division duplex hardware to be utilized for applications where dual duplex frequency bands are required. The system maintains the flexibility of either using the same frequency band or separate bands for uplink and downlink communication. In each case, time-division duplex capability is maintained such that hardware cost and power consumption is minimized.

Those skilled in the art will appreciate that the present invention is not limited to the specific exemplary embodiments which have been described herein for purposes of illustration. The scope of the invention, therefore, is defined by the claims which are appended hereto, rather than the foregoing description, and all equivalents which are consistent with the meaning of the claims are intended to be embraced therein.

<u>We Claim</u>:

1. A base station for use in a wireless communications system including a plurality of mobile stations, said base station comprising:

a transceiver configured to transmit downlink communications signals to said mobile stations via a first carrier frequency and to receive uplink communications signals from said mobile stations via a second carrier frequency, the downlink and uplink communications signals being transmitted and received via successive time division multiple access frames, each frame including a plurality of time slots,

wherein, for each active communications link between said base station and a particular mobile station, a first time slot in each frame is allocated for downlink communication to the particular mobile station and a second time slot in each frame is allocated for uplink communication from the particular mobile station, the first and second allocated time slots being separated in time by a fixed time offset, and

wherein a duration of the fixed time offset can be different for each active communications link.

2. A base station according to claim 1, wherein each time slot in the time division multiple access frames can be allocated for either one of downlink and uplink communication.

3. A base station according to claim 1, wherein said base station is configured to select, for each active communication link, the time slot which is allocated for uplink communications.

4. A base station according to claim 1, wherein said base station is configured to select, for each active communication link, the time slots which are allocated for uplink and downlink communications.

5. A base station according to claim 1, wherein, for each active communication link, said base station is configured to select, on command from a mobile station, the time slots which are allocated for uplink and downlink communications.

6. A base station according to claim 1, wherein each frame is of a duration T and includes a number, 2N, of time slots, each time slot being of a duration T/2N, and wherein the fixed time offset for each active communication link is given by $\Delta T = (T/2N)*m$, m being an integer in a range from 1 to 2N-1.

7. A wireless communications system, comprising:

a plurality of mobile stations; and

at least one base station configured to transmit downlink communications signals to said mobile stations via a first carrier frequency and to receive uplink communications signals from said mobile stations via a second carrier frequency, the downlink and uplink communications signals being transmitted and received via successive time division multiple access frames, each frame including a plurality of time slots,

wherein, for each active communications link between a particular base station and a particular mobile station, a first frame time slot is allocated for downlink communication from the particular base station to the particular mobile station and a second frame time slot is allocated for uplink communication from

the particular mobile station to the particular base station, the first and second allocated time slots being separated in time by a fixed time offset, and

wherein a duration of the fixed time offset can be different for each active communications link.

8. A communications system according to claim 7, wherein each time slot in a time division multiple access frame can be allocated for either one of downlink and uplink communication.

9. A communications system according to claim 7, wherein base stations are configured to select, for each active communication link with a mobile station, the time slots which are allocated for downlink and uplink communications.

10. A communications system according to claim 7, wherein mobile stations are configured to select the time slots which allocated for downlink and uplink communications.

11. A communications system according to claim 7, wherein mobile stations are configured to select the time slots allocated for downlink communication and base stations are configured to select the time slots allocated for uplink communication.

12. A communications system according to claim 7, wherein each time division multiple access frame is of a duration T and includes a number, 2N, of time slots, each time slot being of a duration T/2N, and wherein the fixed time offset for each active communication link between a base station and a mobile

station is given by $\Delta T = (T/2N)*m$, m being an integer in a range from 1 to 2N-1.

13. A communications system according to claim 7, wherein two base stations are co-located to provide complete time and spectral coverage for a particular system coverage area.

14. A method for conducting communications between a base station and mobile stations in a wireless communications system, comprising the steps of:

transmitting downlink and uplink communications signals between the base station and the mobile stations using successive time division multiple access frames, each frame including a plurality of time slots, wherein the downlink communications signals are transmitted from the base stations to the mobile stations using a first carrier frequency and the uplink communications signals are transmitted from the mobile stations to the base station using a second carrier frequency; and

for each active communications link between the base station and a particular mobile station,

allocating a first time slot in each frame for downlink communication to the particular mobile station,

allocating a second time slot in each frame for uplink communication from the particular mobile station, and

selecting a duration of a fixed time offset between the first and second allocated time slots.

15. A method according to claim 14, further comprising the step of co-locating the base station with a similarly constructed second base station to thereby provide complete time and spectral coverage for the mobile stations.

16. A base station for use in a wireless communications system including a plurality of mobile stations, said base station comprising:

a transceiver configured to transmit downlink communications signals to said mobile stations via a first carrier frequency and to receive uplink communications signals from said mobile stations via a second carrier frequency, the downlink and uplink communications signals being transmitted and received via successive time division multiple access frames, each frame including a plurality of time slots,

wherein a downlink signal processing path and an uplink signal processing path of said transceiver share common signal processing components.

17. A base station according to claim 16, wherein said shared signal processing components include at least one of a filter, a local oscillator and a modem.

18. A base station according to claim 16, wherein, for each active communications link between said base station and a particular mobile station, a first time slot in each frame is allocated for downlink communication to the particular mobile station and a second time slot in each frame is allocated for uplink communication from the particular mobile station, the first and second allocated time slots being separated in time by a fixed time offset.

19. A base station according to claim 18, wherein each time slot in the time division multiple access frames can be allocated for either one of downlink and uplink communication.

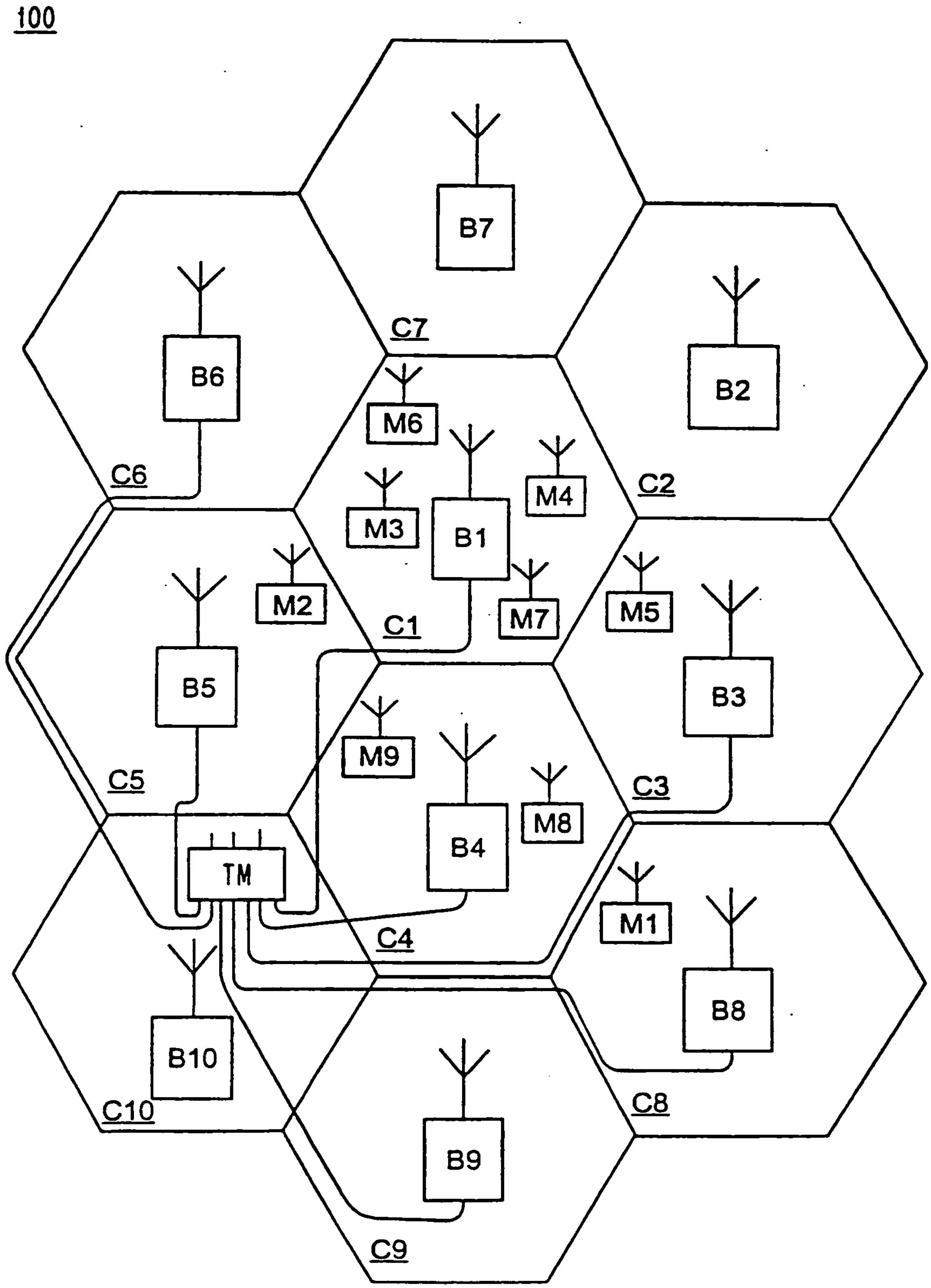
20. A base station according to claim 18, wherein a duration of the fixed time offset can be different for each active communications link.

21. A base station according to claim 20, wherein each frame is of a duration T and includes a number, 2N, of time slots, each time slot being of a duration T/2N, and wherein the duration of the fixed time offset for each active communications link is given by $\Delta T = (T/2N)*m$, m being an integer in a range from 1 to 2N-1.

22. A base station according to claim 18, wherein a duration of the fixed time offset is the same for each active communications link.

23. A base station according to claim 22, wherein each frame is of a duration T and includes a number, 2N, of time slots, each time slot being of a duration T/2N, and wherein the duration of the fixed time offset for each active communications link is T/2.

Fig. 1


100
B7
C7
B6
B2
M6
C6
M4
C2
M3
B1
M2
M7
M5
C1
B5
B3
M9
C5
C3
M8
B4
TM
M1
C4
B8
B10
C10
C8
B9
C9

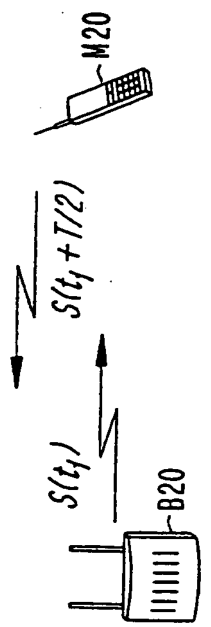

M20
$S(t_1+T/2)$
$S(t_1)$
B20

FIG. 2A

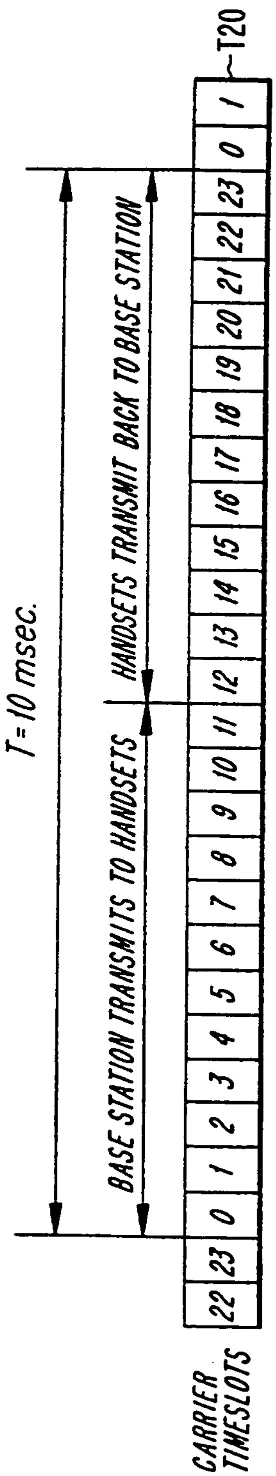

T20
T=10 msec.
BASE STATION TRANSMITS TO HANDSETS
HANDSETS TRANSMIT BACK TO BASE STATION
CARRIER TIMESLOTS
22 23 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 0 1

FIG. 2B

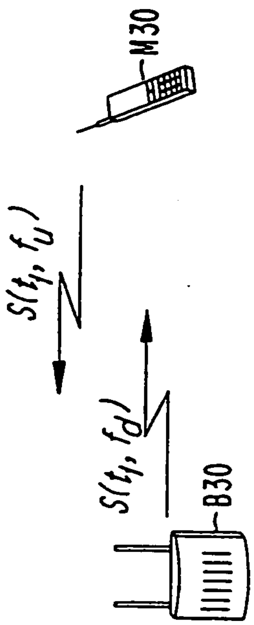

M30
$S(t_1, f_u)$
$S(t_1, f_d)$
B30

FIG. 3A

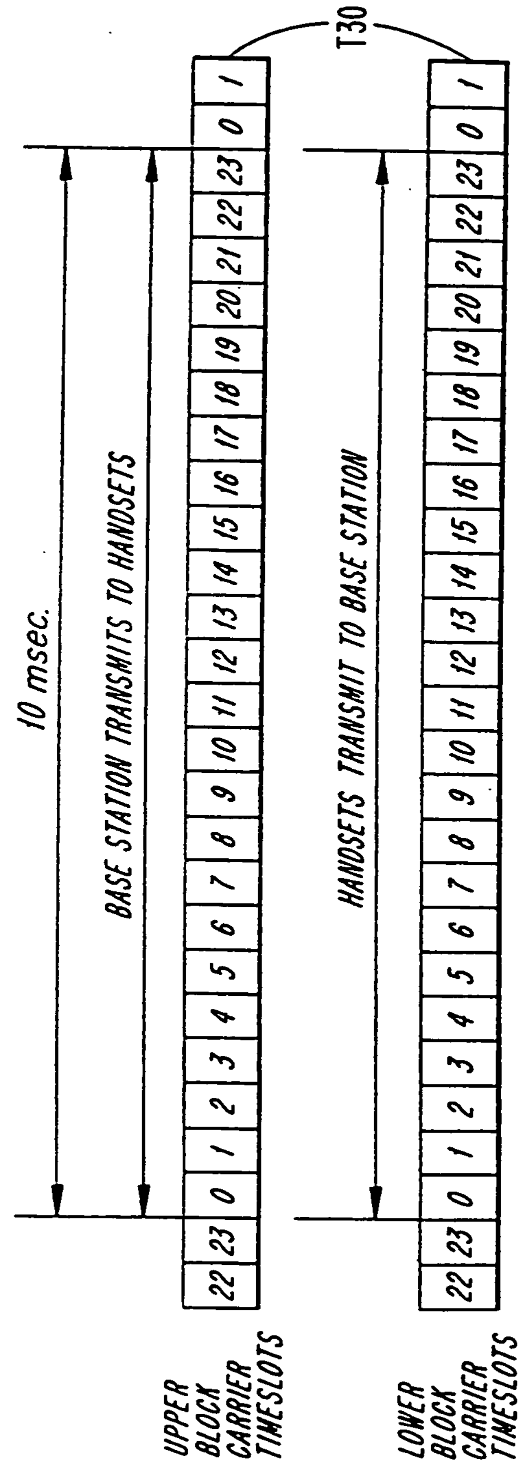

T30
10 msec.
BASE STATION TRANSMITS TO HANDSETS
HANDSETS TRANSMIT TO BASE STATION
22 23 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 0 1
UPPER BLOCK CARRIER TIMESLOTS
LOWER BLOCK CARRIER TIMESLOTS

FIG. 3B

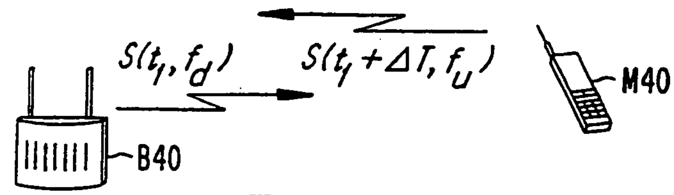


FIG. 4A

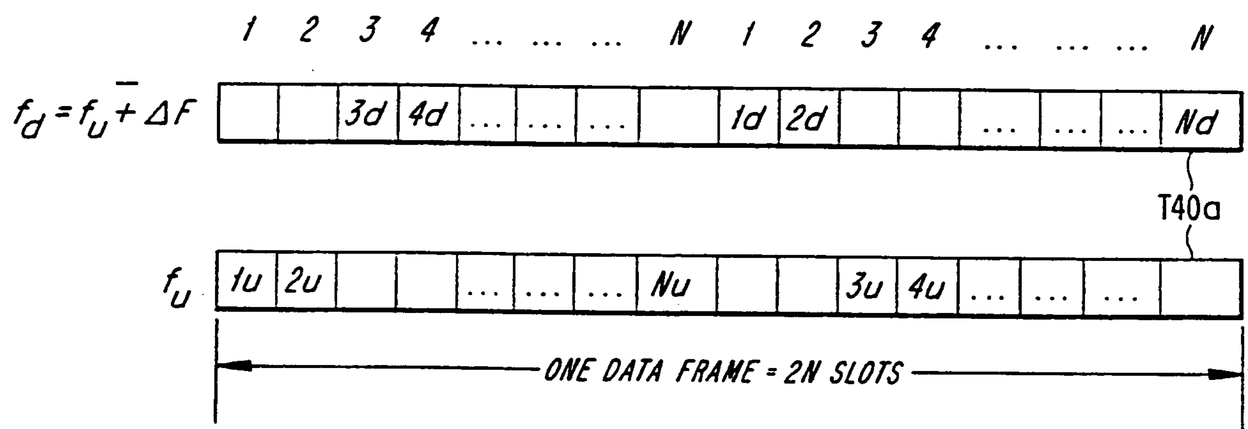


FIG. 4B

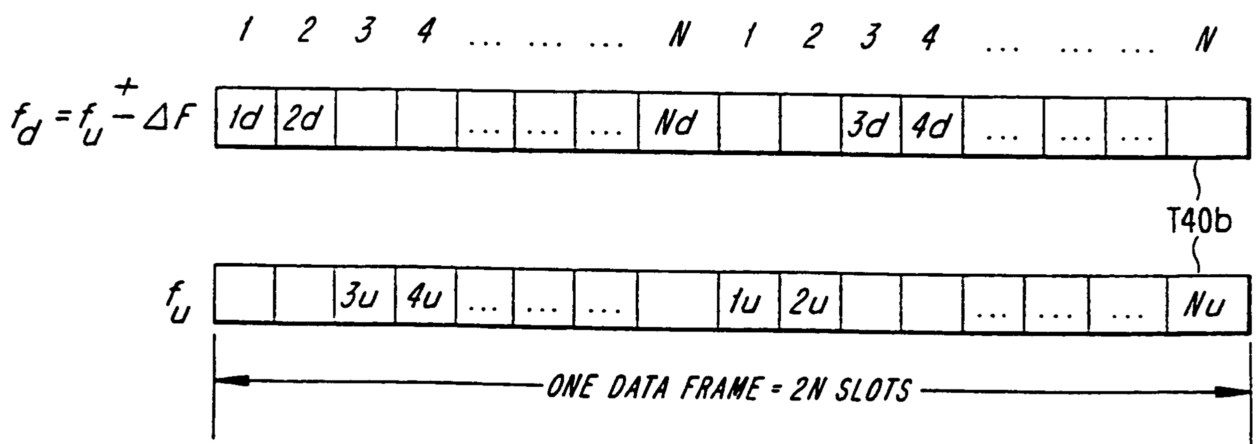
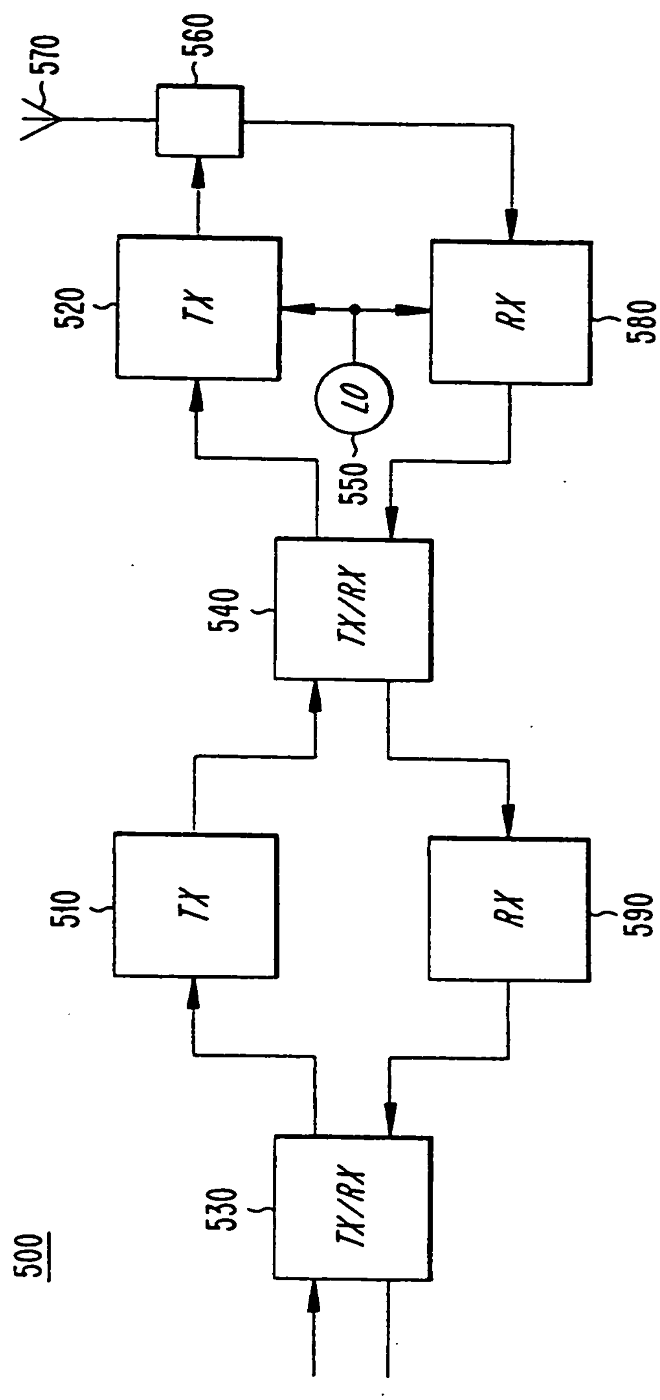


FIG. 4C

FIG. 5



INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/24370

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04Q7/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04Q H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	US 5 689 502 A (SCOTT) 18 November 1997 see column 8, line 59 - column 9, line 10; figures 4,5A	1
A	US 5 617 412 A (DELPRAT ET AL.) 1 April 1997 see abstract; figure 1 see column 6, line 4 - line 13	1
A	US 5 475 677 A (ARNOLD ET AL.) 12 December 1995 see abstract; figure 5 see column 12, line 15 - line 51	1,7,14,16
A	US 5 602 836 A (PAPADOPOULOS ET AL.) 11 February 1997 see column 5, line 1 - line 26; figures 4,5	1,9

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 March 1999	17/03/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Danielidis, S

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/24370

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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International Application No
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			NO	944404	A	26-05-1995
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